Technical Bulletin

2010-07-01

Compensating Injection in the ISO Real-time Market

July 16, 2010

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This bulletin describes the application of Compensating Injection (CI) in the ISO real-time processes.

1. Background

The process of modeling compensating injections (CI) is an automated mechanism used in the real-time ISO market processes (*i.e.,* Hour-Ahead Scheduling Process and the Real-Time Market) to align the modeled flows to account for differences between scheduled flows and actual flows on the interfaces between the ISO Balancing Authority Area (BAA) and the neighboring BAAs. It utilizes pseudo MW injections and withdrawals at a variety of locations external to the ISO to account for unscheduled flows. In the absence of this automated feature, the ISO has the ability to account for unscheduled flows on a manual basis.

Prior to CI implementation, the ISO has used DC circulation to manually counter unscheduled flows and used transmission limit conforming to true up market flows with real-time EMS flows.

After a period of performance testing and parameter tuning, CI will be enabled on a continuous basis in the ISO real-time market processes in the week of July 26, 2010.

2. CI Corridors and CI Generators

CI corridors are the interfaces between the ISO BAA and the neighboring BAAs. An interface can be a transmission line or a group of transmission lines. CI corridors are a subset of all the transmission corridors contained in the CRR FNM.

CI generators are modeled at various locations external to the ISO BAA, where the injection can influence the flows on one or more CI corridors. Since the ISO has modeled significant portions of the network external to the ISO BAA, the CI corridors are influenced by the simultaneous set of CI at the several CI locations.

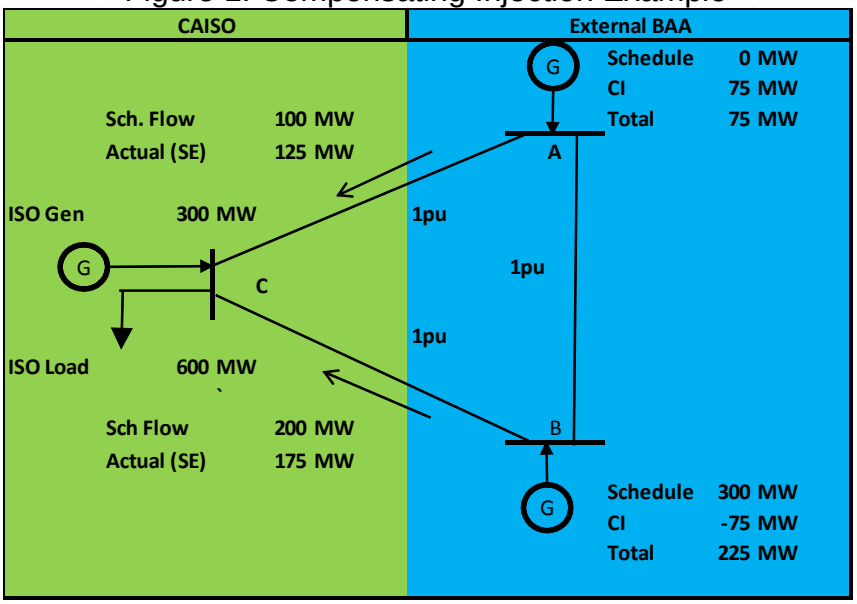
3. CI Process and Impacts

The CI algorithm in the ISO real-time market software optimizes the power flow solution by injecting MW, positive or negative, at each CI generator location. By varying the output of each CI resource, the simultaneous set of CI is optimized by the market software with the objective to minimize the difference in market scheduled flow and the actual flow, as determined by the State-Estimator (SE) power flow, on the set of defined CI corridors. In short, CI accounts for the unscheduled flow effect that is actually occurring in real-time which the ISO real-time market cannot otherwise reflect due to the lack of full network modeling of the closed WECC system and the lack of information about external load, generation and interchange patterns.

CI solution starts with an SE solution which in most instances can have an imbalance of scheduled total net import/export vs. the actual import/export flow. This power imbalance is reflected in the ACE or Area Control Error. CI power flow models the imbalance as the total mismatch of all the CI outputs.

Figure 1 illustrates how CI works. In this example, 300MW of imports are scheduled at Intertie Bus B and 0MW are scheduled at intertie Bus A. Based on the network topology to serve 600MW of load at Bus C in the ISO, the schedules result in 100MW of flow from A to C and 200 MW of flow from B to C. However, based on the state-estimator, the actual flows from A to C and B to C are 125MW and 175MW, respectively. In order for the market flows to match the actual flows it is determined that 75MW of additional compensating injection at Bus A and 75MW reduced compensating injection at Bus B would result in actual flows when added to scheduled injections at Bus A and C.

Figure 1: Compensating Injection Example



While the objective of CI is to match the actual flows at the interface of the ISO BAA and the neighboring BAAs, the CI is expected to also improve the resulting calculated flows internally which should also better reflect actual flow conditions. Once the CI outputs are determined for the current time interval, they are projected forward for the RPTD dispatch horizon. The potential impacts of CI are described below.

3.1. Impacts on Power Flows on Interties/CI Corridors

CI directly impacts the power flow on CI corridors or the interfaces with neighboring BAAs. Except where the external network is modeled as a radial network, the impact of a CI location on the flows of different CI corridors are described by the generation shift factors that particular CI generator on each CI corridor. The shift factors of one CI generator would reflect the degree of

impact it would have on the power flows of number of CI corridors based on the relative location relationship of the CI generator with different CI corridors. Since the intertie scheduling limit is managed as a scheduling limit rather than a flow-based limit, CI will not impact congestion interfaces with neighboring BAAs. However, with the introduction of CI and the resulting real-time market flows that reflect actual condition, the ISO will assess if enforcing the interfaces real-time flows is appropriate.

3.2. Impacts on Internal Power Flows

With improved flows at the boundary interfaces with neighboring BAAs, the ISO expects that improved internal flow patterns will result in reduced false congestion and reduced need to making conforming limit adjustments to the actual flow. Except for major north to south paths like Path 15 or Path 26, the flow improvements will become diminished for network inside the ISO BAA that is further away from the CI corridors.

3.3. Impacts on MSL and ITC Limits

CI is designed to not affect the Market Scheduling Limits and/or Intertie Constraint (ITC) scheduling limit enforcement and the related market results as these limits are based not on flows but rather market schedules. For an MSL the effect of the CI are explicitly excluded. For the ITC limit the ITC constraint is non-flow based constraint and therefore not affected by CI.

3.4. Impacts on external systems

CI may affect the power flow pattern on external systems but such external flow changes will not impact market results since the external network constraints are not enforced.

3.5. Impacts on Area Control Error performance and Mitigation

To the extent the CI are correcting only for the difference between scheduled and actual flows that are the result of the unscheduled flow through the ISO BAA the sum of the all CI and thus contribution to system imbalance is expected to be near zero. However to the extent CI is correcting for flows differences that not associated with unscheduled flow through the system such as inadvertent the sum of all CI may not sum to zero. To the extent the CI's do not sum to zero, there may be an affect on the recovery of ACE in real-time. The main reason behind this potential impact is the forward looking nature of the real-time market. Since CI is calculated in each Real-Time Unit Commitment (RTUC) run and the output of each CI generation is applied and held at the same levels for the three Real-Time Dispatch (RTD) intervals, the resulting market dispatch will assume the imbalance being served by the CI will maintain. To the extent imbalance effect of the CI do not actually maintain the ACE will reflect the difference and AGC resources will need to respond. To mitigate the potential adverse affect of having conditions where CI does not net to zero, the ISO decided to scale the total CI mismatch by a multiplier smaller than 1 when the CI net out greater than 50 MW. The ISO will monitor the effects of the CI parameters and seek to balance the need to

improve power flow patterns and to control the potential adverse effect of total CI mismatch.

It is important to note that CI reduces the power flow discrepancies on the CI corridors but does not necessarily eliminate them due to both controllable and inherent uncontrollable variables and factors.

4. Post Production Monitoring

Based on testing CI in TEST, STAGE and PROD environments, the ISO observed consistent power flow pattern improvements. It was also noted that CI could potentially prolong the time to recover ACE than without the CI. The ISO plans to monitor the market performance after CI is in service on a continuous basis. Based on the analysis of market results, we may consider further revision of the algorithm and tuning of the CI parameters with a goal of further reducing the power flow errors between market flow and SE solutions without unduly affect the ISO BAA control performance.